

# Estimating oceanic physics-driven vertical velocities in a wind-influenced coastal environment

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## Reply to referee #2

We are sincerely grateful to you for the time you spent reviewing our work and for your helpful suggestions. Before answering, please note that we decided to add the latest JULIO time series (from July 12, 2023 to May 22, 2024) to our revised manuscript as we obtained the data during the review process. We think that it brings valuable information on our work as it adds ~ 20% of data compared to the previous dataset in the original version of the paper.

We changed our manuscript accordingly.

### Specific comments

1. Line 224: avoid using the root word “significant” in scientific writing if no statistical tests are conducted. Appropriate statistical tests should be conducted before concluding that the results of all measurement methods are not significantly different from one another. Additionally, the use of scientific notation is not needed if the value is zero (refer to  $0.0 \times 10^{-3}$ ).

We agree, the word significant has been removed (new line 234).

We also changed the scientific notation for zero (new line 234).

2. A sensitivity analysis of the wind speed threshold helps in validating the  $15 \text{ m s}^{-1}$  choice. This is relevant since as mentioned in line 346, Berta et al. (2018) have shown that wind speeds above  $10 \text{ m s}^{-1}$  are strong enough to drive upwelling in the authors’ area of study.

You are right we have decided to follow the wind threshold of  $10 \text{ m/s}$  from Berta et al; We explained our event selection (from line 298 to 305) as follows:

“This work focuses on upwelling and downwelling events. Once the biological-induced signal is filtered, physics-driven events identification follow four criteria in the following order. We first identify groups of physics-driven vertical velocities with intensities greater than  $\pm 10 \text{ mm/s}$  lasting at least 2 hours (5 values) and spreading deeper than  $\approx 10 \text{ m}$ . If the criterion is met, we look for groups of horizontal velocities in the proximity of the identified W, that match both intensities greater than  $\pm 200 \text{ mm/s}$  and offshore (onshore) directions, consistent with an upwelling (downwelling) event. If these two criteria are met, we analyze wind speed intensity and direction from ARPEGE model, keeping episodes where intensities are over  $10 \text{ m/s}$  (Berta et al. 2018) and directions are north-westerly (south-easterly) to match offshore (onshore) horizontal currents. Finally, this whole identification is completed by an analysis to detect the expected variability in SST (SLA) satellite observations leading to the upwelling (downwelling) event identifications.”

Nonetheless we also observe that our chosen events corresponded to stronger gales ( $15 \text{ m/s}$ ).

3. Lines 11–13: the authors in the abstract highlight how the order of magnitude of W depends on the spatiotemporal scale of its analysis and also the need for high-frequency measurements. The statements are not only unclear, but also feel random and out of place because there is hardly any discussion on how different sampling frequencies affect the final results of the study.

Thank you, we have deleted the statement in the abstract as our Fig 10 (now Fig. 7) is not temporally averaged over a 4h time window anymore.

The frequency measurements at JULIO (48 per day) is adequate for the physical processes (upwelling

and downwelling events) targeted in this paper. FF-ADCP measurements, with a sampling every 2min, would have been a more appropriate tool if we had chosen to study internal waves for example.

4. Section 3.6 and Figure 10 should be placed before Section 3.5 and Figures 7–9 for better structure and flow. Describe the general trend and features (e.g. the total number of upwelling and downwelling events identified in the entire time series) before moving on to describe the specific events in detail.

We have followed your suggestion. The manuscript's flow should be more fluid now. In the new version, after the comparison between the three methods to place a context around the values obtained at JULIO, we give an inter annual overview of all vertical velocities combined (physics-driven and biological-induced) to show the phenomena that can be observed there. Then we explain and apply our biology filtering method, showing a specific example before applying it to all time series. Then we present our identification method for upwelling/downwelling events and focus on four specific examples.

5. I also suggest adding the adjective “physics-driven” in the title to better reflect the scope of your study.

Thank you, the new title definitively reduces ambiguities.

6. The organisation of the manuscript can be further polished and requires a thorough proofreading. There are many short paragraphs that are 1–2 sentences long (e.g. lines 54, 93, 339, 350, 387, 389, 404) that could instead be integrated with other relevant text to produce longer coherent paragraphs.

Indeed, we had split paragraphs into separate ones without it being necessary. The new manuscript should be more readable now.

7. Some descriptions and ideas are repeated often, thereby reducing the brevity of the manuscript. One notable example is the Discussion section, where some paragraphs are largely a rehash of the results presented in section 3.5. To improve the structure of the paper and make it more concise, here are some key suggestions:

- Move lines 96–99 to section 2.2.
- Move section 3.6 in front of section 3.5 (as mentioned earlier).
- Move the bulk of the description in lines 324–333, lines 354–363, and lines 365–374 to section 3.5, and reduce the repetition.
- Lines 337–338: sentence is phrased like a summary statement that is placed awkwardly in the middle of the Discussion section. I suggest removing it.

Thank you for your suggestions.

- We decided not to move lines 96–99 to section 2.2 as we wanted to describe the rather scarce W estimations in our area of study in the introduction.
- The section 3.6 has been moved before section 3.5 to improve fluidity of the article.
- The description lines (old version; line 324–333, lines 354–363, and lines 365–374) have been moved to a new section (3.7 new lines 343–348, new lines 349–357, new lines 362–372) prior to the discussion section, which includes the comparison of the four events characteristics.
- The sentence (old version; lines 337–338) has been rephrased to “As the first measurement of vertical velocities associated with upwelling or downwellings detected with an ADCP in the Northwestern Mediterranean Sea were presented here, it is noteworthy to underline different

upwelling systems, and their associated vertical velocities, which have been studied in other coastal environments” (lines: 402-404), as a transition to introduce other upwelling systems in different areas.

### Technical corrections

Thank you, all these comments have been taken into account according to your suggestions.

Line 1: change to “oceanic vertical velocities (W)”.

Changed.

Lines 11–12: Write “w” in caps.

Deleted sentence.

Line 13: remove “spatiotemporal”.

Deleted sentence.

Line 18: change to “allowed for”.

New line: 20.

Line 22: awkward use of colon.

New line: 24.

Line 24: the word “very” is redundant since “complete” is already an absolute adjective.

True. The sentence has been rephrased to “A complete summary of submesoscale mechanisms, [...]”, new line 26.

Line 27: change from “during the last decades” to “over the decades”.

New line: 29.

Lines 35, 40, 364, 383: the phrase “allow to” is used awkwardly, please rephrase.

- Line 35, new line 37 changed to “allow estimating”.
- Line 40, new line 42 changed to “With other 3-month observations in the same area by Clément et al. (2024) measured, using gliders, downwelling (upwelling) convective plumes [...]”
- Line 364, new line 361 rephrased to “Despite the proximity to the coast, satellite observations appear consistent and are enhanced by SST in situ observations (Fig. 9).”.
- Line 383, new lines 428-429 rephrased to “Using a meteorological model as a prediction tool could help to set up dedicated cruises [...]”

Lines 41, 76, 88, 234, 326, 334, 367, 373: I suggest against starting a sentence with “indeed”. It is a filler word that hardly adds or change any meaning to the overall flow.

Thank you for pointing this. We changed it accordingly:

- Line 41, new line 43-44 rephrased to “. In Christensen et al. (2024), Argo floats were used to estimate values [...]”
- Line 76, new line 78 “Indeed” has been removed.
- Line 88, still line 88 “Indeed” has been removed.
- Line 234, new line 255 “Indeed” has been removed.
- Line 326, new line 344 “Indeed” has been removed.
- Line 334, new line 400 “Indeed” has been replaced by “In particular”.
- Line 367, new line 366-367 the sentence has been rephrased. “ We observe much more W variability through time in upwellings than downwellings.”
- Line 373, new line 372 “Indeed” has been removed.

Line 66: awkward use of colon. The part after the colon is also repetitive and redundant.

New line 67 the colon has been removed.

Line 72: “..., seasonal variability affecting its width, ...” – awkward phrasing.

New lines 73-74, rephrased to “Originating from the Ligurian Sea, this density current follows the coast with a horizontal speed from 0.4 up to 0.7 m/s in winter, with a width, depth and flow rate that are prone to seasonal variability (Petrenko, 2003).”

Line 121: no need for a new paragraph.

New line 127, changed.

Line 144: change to “information”.

New line 149.

Line 149: remove the extra blank line.

Deleted, new lines 153-154.

Line 156: add a space between number and unit (i.e. 4 m).

New line 161.

Line 168: add a space between number and unit (i.e. 2 Hz).

New line 177.

Line 183: spell out 8 and write one as a numeral. For items other than units of time or measure, use words for cardinal numbers less than 10. Add a space between number and unit (i.e. 200 m).

Thank you for your comment. The changes have been applied in new line 193.

Here, we refer to attitude angle as used in Comby et al. 2022.

Line 195: change to “10 m”.

New line 205.

Line 210: change to “resulting in”.

New line 220.

Line 238: change to “example”.

New line 259.

Line 240: present your results in prose instead of a bullet point list.

Changed from line 260 to 263. “Strong negative vertical velocities appear in patches (with averaged  $W$  in the patches =  $-1.8 \times 10^{-2}$  m/s), describing a diurnal cyclespanning  $\approx 8$  hours and centered at midnight. Those patches are located mainly under the surface (between the surface and  $\approx 50$  meters depth) with a seasonal variability and a more pronounced presence in springtime (Fig. 5).”

Line 243: remove “a”.

The sentence has been changed (see previous comment).

Line 267: remove “respectively” in parentheses.

The entire sentence has been removed.

Line 268: awkward use of the word “completed”. Sentence is thus unclear.

New lines: 304-305. The sentence has been removed as we detail our event identification method instead.

Line 275: change from “of” to “in”. Use “of” to describe the magnitude.

New line 320.

Line 285: change to “small decrease of”.

New line 330.

Line 295: change to “24-day long”.

New line 340.

Line 302: change to “variability of”.

New line 348.

Line 331: change from “upwelling and downwelling  $W$ ” to “upwelling and downwelling events”.

The sentence has been removed.

Line 348: remove “a”.

New line 414.

Line 365: change to “With a shorter”.

New line 364.

Line 383: sentence is unclear with some awkward phrasing.

New lines 428-429. The sentence has been rephrased to “The use of a meteorological model as a prediction tool could help to set up dedicated cruises with the VVP and FF-ADCP during or right after a strong wind episode (such as Mistral or south-easterlies).”

Line 402: “arise the question of 2012” – unclear.

We noticed that biology-induced  $W$  during spring and summer in 2012 are less numerous than other years (2021 to 2023). If we compare the number of biology-induced  $W$  (number of green dots on Fig. 7 which was previously Fig. 10) from April to June for each of these years (same number of

measurements), we find:

- 255 in 2012
- 749 in 2021
- 806 in 2022
- 353 in 2023

For now, we don't have the necessary perspective to interpret these differences but long-term observations might be useful to conclude if 2012 is an exceptional year.

Line 403: write "w" in caps.

New line 450.

Line 404: change to "for the first time".

New line 451.

Lines 406–407: add a space between the number and kHz.

New lines 453–454.

Figure 1: intensity or velocity? Add a scale bar. Are the locations of the VVP and FF-ADCP the same as the JULIO mooring? If not, label them on the map.

The Figure 1 shows the intensity of horizontal velocities. A scale (10 km) bar has been added. The VVP and FF-ADCP locations are the same as the JULIO mooring; we precised it at line 230 to reduce ambiguities "Three W measurements have been made simultaneously in space and time at the JULIO site in 2022: JULIO's mooring ADCP, VVP, and FF-ADCP (Fig. 2)."

Figure 2: the font size of the title is too small.

We increased the titles font sizes.

Figure 6: in the caption, the panel labels (a) to (d) should precede the description of each figure panel, not after.

Thank you for pointing this. We changed the caption accordingly.